

Citation for published version:

Fodde, E 2007, 'Traditional Earthen Construction and Repair Methods in Sardinia, Italy', *Vernacular Architecture*, vol. 38, no. 1, pp. 61-69. <https://doi.org/10.1179/174962907X248056>

DOI:

[10.1179/174962907X248056](https://doi.org/10.1179/174962907X248056)

Publication date:

2007

Document Version

Peer reviewed version

[Link to publication](#)

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TRADITIONAL EARTHEN CONSTRUCTION AND REPAIR METHODS IN SARDINIA, ITALY

Enrico Fodde

While vernacular earthen construction has been widely studied, little has been published on traditional repair techniques. By using a combination of technical analysis and interviews with elderly craftsmen, this paper demonstrates that until recently in Sardinia, specific specialised solutions were available in contrast to the situation prevailing elsewhere, notably in Britain.

INTRODUCTION

The region of Campidano (the term is synonymous with the Latin *campus* meaning field or open area) in southern Sardinia is largely flat and surrounded by mountains and the Mediterranean Sea¹. It has been vulnerable to invasion since Carthaginian and Roman times and consequently dwellings tend to be clustered in villages away from the sea. Both the winter and summer climate is extreme. The form of the farmhouses is dictated by the need for defence and the provision of shade, introverted spaces with living quarters for humans and farm animals and storage buildings set around internal courtyards. With very few external openings, these buildings create a harsh street landscape. Building materials are restricted to what was largely at hand –stone and earth mixes (the latter used as early as the seventh century BC) and evidence has been found to suggest that the technique of *tapias*, or earthen blocks, was used in Sardinia in 1567 and then abandoned in favour of mud bricks².

The agricultural landscape of Campidano was organised according to peculiar rules with medieval origins. Le Lannou³ describes its character:

Once out from the village, one may find an area where relatively small fields delimited by prickly pears are cultivated with legumes, almonds, olive trees and vineyards. But this is just a small strip that dissolves into the bare cultivated open fields, without boundary walls, hedges or trees that constitute the ancient *viddazzone* where paths are designed radially.

One half of the arable was cultivated and the other left to rest fallow for one year. The land beyond the *viddazzone* was known as *saltus* and was used mainly for grazing. This concentric medieval organization of the area surrounding the villages of Campidano is reflected in the settlement morphology: villages have a circular layout because they are the result of the gradual addition of many courtyard houses over time. Size of farmsteads relates to that of the holding⁴: ‘... courtyard areas are proportional to the surface area of the cultivated land’. Consequently, the grandest vernacular architecture in Campidano relates to the size of the estate, the wealthiest owners being able to afford highly sophisticated houses that incorporated a series of annexes such as the mill, the well, a house for servants, storage rooms, the stable and the barn (Figs.1 and 2).

A barter economy for both commodities and services - *aggiudu torrau* or 'returned help' - prevailed until the 1940s⁵. The region's physical remoteness exacerbated its economic insularity. It took thirty-six hours in the late-nineteenth century to travel by ship between Genoa and Sardinia's main port, Porto Torres (reduced to ten hours by 1941) and the railway journey covering the 200 kilometres between Cagliari and Sassari took nearly eighteen hours at around the same time⁶.

CRAFTSMANSHIP AND ORGANIZATION OF THE BUILDING SITE

The professional qualification of architect was only introduced in Sardinia in the twentieth century to replace the role of the building site supervisor, the *maistru de muru*⁷. In the first half of the twentieth century, craftsmen were hierarchically organised according to the level of experience gained during their apprenticeship: the *manovaleddu* (the young non-experienced worker started in the profession by carrying out the lightest work consisting of menial or basic tasks); the *manorba* (the *manovaleddu* could be upgraded to *manorba* only after a couple of years of apprenticeship after which he was allowed to lift heavier building materials and to mix mud and lime); the *apprendista* (the *manorba* generally became apprenticed at the age of eighteen and was expected by this stage to be experienced in laying bricks and stone); and only a few *apprendisti* went on to become specialised craftsmen or *maistru de muru* at the average age of twenty-five. The latter was the most experienced craftsman who was proficient in all aspects of building from foundations to roof.

Both verbal and written agreements between master craftsmen and clients were common by the twentieth century, but these had deep roots in historical practice. The earliest contract between a craftsman and client for the construction of an earthen building dates to 20 September 1567⁸. Once agreement was reached, the *maistru de muru* had to gather together the necessary men for the construction of the specific building. No work was carried out prior to construction, except for a full-scale sketch-plan, which the master craftsman usually made on the ground with wooden sticks and string. This was designed to provide the patron with an idea of the layout and the size of the building. After the layout was agreed, lime putty mixed with sand was used for building stone plinths, which ideally were laid on the whole perimeter of the construction without interruption.

Scaffolding was made of timber boards and posts to form a level platform. In some villages scaffolding was cantilevered by inclining two iron bars (*trampabis*, 30 mm in diameter) in the vertical joints of the mud brick wall (in the *cummussura*) to support the boards. Bricks were often thrown up from the ground to one intermediate level of the scaffolding and then thrown again to another craftsman positioned on the top of the wall. The bricks were stacked on top of the wall and mud mortar raised to the wall head in wooden baskets that formed a platform for the craftsman to stand on during the construction of the next course. Mud brick had to be completely dry because their interface with the fired bricks used for dressing corners (*contonara*) or the arches of portals would be subject to dislocation if substantial shrinkage occurred whilst drying out (Fig. 3).

MUD BRICK MAKING

Soil selection and the making of mud brick in Campidano differed from area to area, according to the availability of materials. Mud brick makers moved to those fields where soil was readily available and the landowner often charged the craftsmen by the brick.

Mixing techniques

There were numerous traditional mixing techniques. The simplest method consisted of digging the soil with a mattock to break up the largest lumps of clay, after which it was wetted with buckets of water and left to soak overnight. A more sophisticated mixing technique consisted of piling up the soil in the shape of a truncated pyramid to a height of one metre⁹. Craters were dug on the top of this pyramid and water poured in and left to soak overnight. The following day the soil was mixed by bare feet, watered again, and mixed with wheat straw in percentages that varied from village to village. The amount of straw and water was directly proportional to the content of clay in the soil. The traditional test for a good mix was that if a sample could slowly slide from the shovel (or from the mould), it was ready for use¹⁰. The proportions of soil : water : straw are of 1:1:0.23 cubic metres¹¹. These proportions would allow the moulding of 125 bricks (size of bricks 10x20x30 cm).

Mud brick moulding and drying

When the mix was ready (Fig. 5), bricks were manufactured (*pesai su làdiri*) with a wooden mould (*sestu*) made of four sides, with two handles and without a base. The mould was filled with mud and its four corners compacted (*accraccangiai in is orus*) in order to make crisp bricks that would later form straight walls. The mould was then hand-levelled with the help of some water and emptied to the flat drying ground covered with straw. Bricks were turned and left to dry for a number of days before use, which was commonly five days in summer. When the drying process was over, every brick had to be checked and its corners trimmed and made sharp (*arrasigadura*) with a hooked tool called a *pudazza*. (Fig. 6) Once dried, bricks could either be stored (*abbigadura*) away from rain and damp, or immediately used for building. During storage, a gap of at least three centimetres was left between bricks and this allowed complete drying.

Mud bricks were tested by moulding one brick and allowing it to dry for four days; if the brick did not show any cracks, it was considered to be of good quality and brick making could start. Mud walls were built in layers 50 cm high, corresponding to 4-5 courses of mud bricks, in order to allow drying of the mortar. When mud bricks were irregular in shape, courses were kept flat with the insertion and the dry packing of wedges of mud brick. The mortar for laying bricks (*ludu po ghettaì làdiri*) was sieved from the same soil used for mud brick moulding (the aggregate size being no larger than one centimetre in diameter).

Admixtures

The quality of mud brick was the responsibility of the experienced moulder himself and his skill was particularly relevant when the quality of soil was inadequate. The craftsman had to draw on all his skills to compensate when the soil was not coherent or plastic enough by adding an appropriate proportion of straw in order to mould bricks of a sufficient standard. Admixtures such as cow dung or blood were probably employed in concentration close to 2-5% by volume and gave the mix a remarkable cohesive strength.¹² The resulting increased water resistance of the mud brick was an unintentional - though welcome - side effect.

Tools for mud brick making

Tools for the making of mud bricks vary little from one part of Campidano to another. The mattock was used for mixing soil with water and straw¹³. The mix of soil and straw was brought to the moulding area in a trapezoidal wooden container –filled by shovel- which could hold exactly the right amount of mix for two mud bricks. The moulds (Fig. 5) were made with boards of 2.5cm thickness, with two handles. The dimensions of dry bricks were 10x20x40cm and other dimensions maintained the proportion 1x2x4. Bricks for use in the construction of hemispherical ovens were called *ladireddu* (small *làdiri*) and were made with a truncated pyramid mould (*sestu pitticcu*) with two handles. These smaller bricks were 18x10.5cm wide on the principal face and 12x8.5cm on the minor side and 20cm high¹⁴. Their shape facilitated the construction of the dome of the oven without the need for centering. The tool called *pudazza* was made of a timber handle 10cm long and a hooked steel knife 15cm long. Its main use was in the pruning of vines, but it also was used for the cleaning of corners of the bricks after drying occurred¹⁵ (Fig. 6). Bricks had a slight concave shape due to their own weight when drying and laid with concave side down. In so doing bricks could set firmly in the mud mortar and water could be forced to move downward to the outside of the surface where evaporation could occur¹⁶. After a course was laid on the mud mortar, bricks were gently beaten with the top of a pickaxe (*piccu*) in order to improve bonding¹⁷. Mud mortar for the laying of bricks was transported with buckets passed from hand to hand along a human chain. When bricks had to be cut, especially for conservation purposes, a special tool called *marteddu a tallanti* was used. It was basically a hammer with one sharp side similar to an axe. After four grooves were impressed in the four sides of the brick to cut, the hammer was used to cut the brick and to remove lumps.

TRADITIONAL REPAIR METHODS

The traditional repair methods illustrated here can seldom be identified on buildings since they are often concealed by render. In some cases master craftsmen were able to show the author the repairs they carried out half a century ago on specific buildings (Fig 4).

Stone underpinning courses

Stone plinths built with mud mortar are obviously more susceptible to the erosion of joints than those built with lime mortar. Deeply eroded joints of the stone plinths were first cleaned of all loose mortar and then repaired by inserting a grid of wooden sticks in the

joints. This was a method which was also used for the repair of eroded mud walls. The sticks were necessary to create a structure on which to build the repair work of stone wedges and mortar which were inserted in the joints. Dry packing was then carried out in order to tighten the stones to one another. This technique was somewhat more complex than regular maintenance procedures, which were typically restricted to the simple repointing of stone plinths and portals with lime or mud mortar.

Stone underpinning courses attacked by salt content or by serious settlement were repaired with the method called *rincasciu*. This consisted of the extraction of the stones of the central part of the wall for a length of 50-60cm. This was the maximum length that gave craftsmen the freedom to prop up the wall above without causing collapse. Then the original (or new, according to the degree of decay) stones were re-laid with lime mortar. In order to cause a tightening effect, the last course (at a distance of six centimetres from the first mud-brick course) was built with battered faces on both sides and dry-packed with tile or stone wedges until it was flush with the wall (*rincasciai*). This procedure was necessary to avoid the last course causing cracks and detachment after shrinking. After the central section of the plinth was dry, the symmetrical zones (measuring 50-60cm in length) were propped up and repaired at both ends of the wall, at a minimum of three metres from the centre of the wall. After these two areas were repaired, the craftsmen could circumnavigate the wall and repair two more zones located at a distance of three metres from the last. In more recent practice, master craftsmen inserted a sheet of tarred paper at the base of the wall. The *rincasciu* method permitted continuous repair along the perimeter of the wall to resist attack from salts. It was successfully used in many buildings of the village of Uta after the historic flood of 1929, for example, when numerous earthen buildings were subject to serious plinth erosion. The advantages of the methods explained above are many, especially because they could be carried out without causing any cracks in or collapse of the mud-brick structure.

Decayed structural quoins in portals and loggias were commonly replaced with new stones. After the size of the stone was measured, the stonemason chose the most adequate block to be dressed in the quarry site. The stone was then transported to the site of the building and put into position by the master craftsman, who was often helped by the stonemason himself.

Mid-wall structural cracks

The aim of this section is to illustrate two traditional conservation techniques for the repair of cracks on earthen walls as explained by several twentieth-century craftsmen of Campidano.

Traditional prevention methods

When the soil used for making mud bricks was of poor quality, or if the wall was poorly constructed, a preventive system of wooden ties against cracks was inserted in the wall corners during the construction of the building itself. When the building of the ground floor was completed, juniper or iron ring beams (*radicciamento*) were applied all along the wall and tied together with keys (*chiavi*) and steel straps (*bolzoni*). Archival research carried out

in the village of Quartu Sant'Elena shows that keys and steel straps were allowed to protrude from the wall, whilst trusses and beam ends had to be kept flush. This is confirmed by the author's direct observation not only in Quartu Sant'Elena, but also in several other villages of Campidano. Juniper ties were applied on both internal and external sides of corners, alternatively and 50cm apart (roughly every four brick courses). In recent practice timber ties were replaced with recycled railway tracks or with iron rods (diameter 1.8cm) which were bedded with cementitious mortar to create a continuous ring beam. By comparison, the traditional practice of inserting fired bricks for the building of corners did not appear to be effective against lateral movement of walls because mud bricks and fired bricks have different porosity, density, and coefficient of expansion and contraction. Detachment of fired from mud brick walls is today visible in many buildings as a consequence of this. Master Craftsmen explained that the regular inspection of gutters was of great importance towards the prevention of cracks because, if water was allowed to penetrate the wall, iron ties could rust and cracks could start to appear. In this case ties were replaced and the repair of cracks followed Walls which are not tied to each other due to poor craftsmanship are quite frequently encountered in Campidano, especially in the connection between boundary walls and portals, suggesting that because boundary walls were not of primary importance, craftsmen concentrated their efforts on the principal building.

Traditional stitching method

In some cases structural cracks were cleaned of all loose material and plants, wetted and filled in with tiles or flat stones, mud mortar, and dry packed. Skilled craftsmen explained that structural cracks were stitched by inserting juniper or chestnut ties (or hooks) in order to establish a solid connection of the two parts of the wall (Fig. 7). The reason for using timber is related to its compatibility with earthen buildings, being flexible and vapour-permeable. The stitching method restricted further movement, but did not eliminate of the underlying cause. If, for example, a crack measuring two metres in length was to be stopped from expanding, two ties were inserted at 50cm from both extremities of the fracture. In order to do so, a chase 20cm deep - exactly half the thickness of the wall - was cut in order to accommodate the timber tie which was then fixed at both ends with two timber wedges. One end was fixed first and then the other extremity was fixed and tightened with a cross-tie end-securing method. Ties measured 10cm in diameter and one metre in length and were characterised by two dovetail holes at both ends, and by two end-securing methods (*crai*, key, or *cravatta*) with a vertical and a diagonal side. Ties were fixed on the wall and keys were hammered in the holes and kept tight by simple friction (*attesai*), without any nails (*obbibisi*) or wedges (*taccius*). Some master craftsmen agreed that the longer the keys, the greater the benefit against cracks. Then the timber tie was bedded in and packed with mud mortar and tile wedges in order to complete the stitch. A certain amount of original fabric was lost when cutting the chase on the wall and the method presents philosophical conservation issues as a model for repair techniques. However, the alternative technique of grouting liquid clay into the crack was not traditionally contemplated by craftsmen as in their experience, clay could shrink after drying.

Holes caused by burrowing animals

Before dealing with the repair of rat runs caused by rodents, traditional craftsmen located the extent of the holes, as these could stretch through the whole depth of the wall. Holes and missing units were traditionally repaired by cutting a brick in the shape of the lacuna, following which the surface was wetted and a layer of mud mortar was laid in the cavity. The brick was then hammered in with the help of a timber board. The area of contact between old and new fabric was then packed with stone wedges and dry soil. Erosion of lower level of a wall by rodents was traditionally prevented by means of inserting sheets of chicken wire with a mix of mud mortar or by filling in the cavity left by the rodent with a mix of mud, stone wedges, broken tiles, and broken glass. The latter technique was also traditionally used for the repair of rodents damage in cob walls in England¹⁸.

Eroded walls

The aim of this section is to illustrate the traditional repair methods for eroded earth walls. Traditional craftsmen explained that wall erosion was repaired according to its depth, different methods being adopted for shallow (<10cm) and deep (>10cm) erosion.

Shallow erosion

Shallow erosion was often accepted in Campidano as being a characteristic of the fabric of the earthen wall face which did not require any repair beyond good-quality plaster. The traditional solution for shallow erosion (<10cm) was the preparation of the wall by the insertion of broken tiles or flat stones in the vertical joints (*cummussura*) of the mud brick in order to form a keying system (Fig. 8). Before insertion, joints had to be dug in order to be able to accept the broken tiles and the lime mortar. After the system of tiles and stones was firm, a lime slurry was applied to the eroded area over which, after drying was completed, a coat of lime mortar of thickness 5-10 mm was plastered. A combination of coats was preferred to a single thick coat in order to avoid drastic detachment. Generally speaking, the thickness of every coat was proportional to the depth of the erosion.

Another traditional method for the repair of superficial erosion entailed the use of broken roof tiles (*teullacciu*) and of flat stones applied parallel to the eroded area (Fig. 9). This created a continuous layer on which the lime render could grip and form a flush surface with the wall line. Patches of loose soil were traditionally consolidated by spraying a lime slurry in order to take the wall back to its original state. It was important to soak the broken roof tiles and the stones in water before use, and to moisten the wall before accepting them. This technique has an ancient origin, as demonstrated by discoveries in the House of Phaunus in Pompei¹⁹ and in Sardinia in the Roman site of Nora. Here earth and stone walls were repaired with a coat of roof tiles bedded in lime mortar, showing that this technique was most probably transmitted during the centuries of Roman control in Sardinia.

Deep erosion

In villages such as Sinnai and Villamassargia deep erosion was especially frequent at the base of the mud wall (coving), and was repaired by using the traditional method known as *rincasciu* (Fig. 10). This procedure involved a preliminary brushing-off of all loose earth of the wall surface. If necessary, patches of loose soil were consolidated by spraying a lime slurry on the affected area. Then a rectangular chase with a sloping soffit was hacked into the extremities of the eroded area to form a dovetail section in order to receive a series of pointed wooden sticks (*ancrava*) tapped into the vertical joints of the mud bricks. It should be mentioned here that this is a similar procedure to that adopted by Pearson for cob buildings in the UK²⁰. Sticks were made of juniper or oleaster and measured 2-3cm in diameter and were necessary when erosion was deeper than 10cm. Hammering was carried out until the extremities of the sticks were flush with the original wall line. In order to avoid cracks caused by hammering sticks on a square grid basis, a diagonal grid (*pei tremini*) with sticks 30-40cm apart was preferred. This was necessary to create a tight and solid structure that could form the basis onto which the subsequent step of the intervention could be keyed in. After a flush line was fixed, the chase was wetted and filled in with courses of broken roof tiles, fired bricks, flat stones (*mazz'e cani*), and mud or lime mortar. Sticks therefore had the function of tying these courses to the wall. The use of chicken mesh and nails, typical of modern cementitious repairs, was traditionally avoided because of the certainty of rusting when associated with lime. In some cases pre-shrunk earth bricks were employed instead of fired tiles. Clay bricks were made of the same loam as the historic wall. When fired clay tiles were used instead, traditional craftsmen suggested that this had the disadvantage of sacrificing the surrounding mud bricks to the fired tiles because moisture could be drawn to where the material is softer.

CONCLUSION

In the evidence assembled, the assumption is that the methods explained here are indigenous to Sardinia. However, the author was not able to demonstrate this conjecture because of the lack of literature on the subject. Some of the methods explained could be dated back to the Roman period, whilst others are similar to standard repair procedures of other building cultures. This discussion demonstrated that the repair of earthen buildings was often a codified activity and that traditional craftsmen associated specific methods with specific decay symptoms. Another important outcome of the study was that such schemes were, for the majority of cases, evaluated in a positive light in terms of philosophy and ethics of conservation (if the assessment is carried out through these categories: minimum interference with the historic fabric, recycling of materials, and repairing like with like). The need for testing such repair schemes should be urged as a future task. This would allow to ensure the long-term effectiveness of the methods explained.

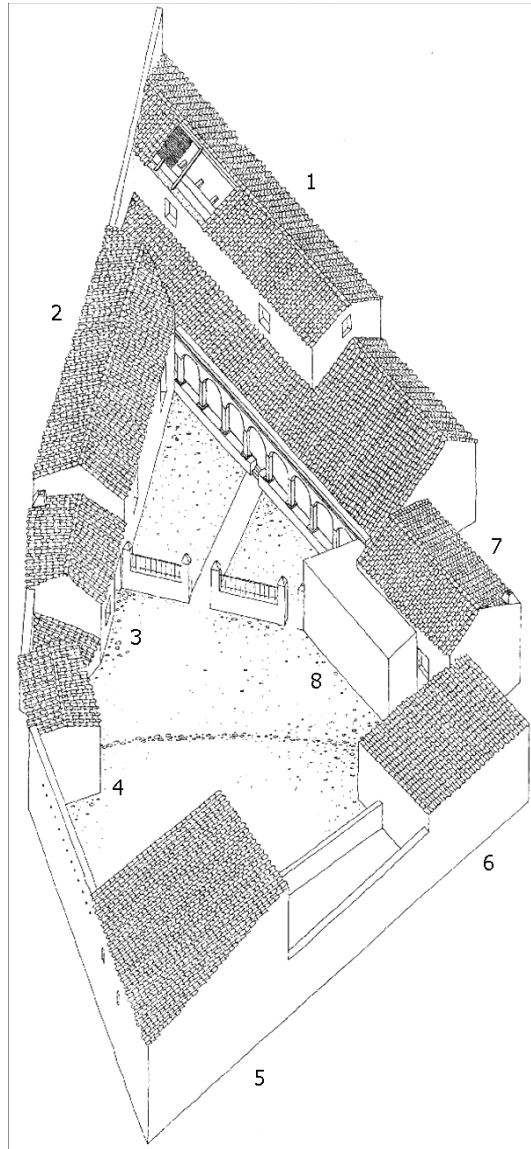


Fig. 1. Courtyard farmhouse, Sinnai. It is a typical introverted space with few or no openings to the outer walls. The illustration shows: residential area with porch (1 and 2), small kitchen with oven for the preparation of bread (3), entrance portal (4), shelter for farm animals (5), storage facilities for wheat (6), and kitchen (7). In many of such buildings one can find 1960's additions made of cementitious blocks (8).



Fig. 2. Nineteenth century courtyard farmhouse showing shaded loggia and cobbled paving (village Ussana)



Fig. 3. Granary entrance showing mixed use of stone and mud brick (Villaurbana)



Fig. 4. Typical decay patterns in a boundary wall (Serramanna)



Fig. 5. Mud brick making



Fig. 6. Cleaning bricks from protrusions

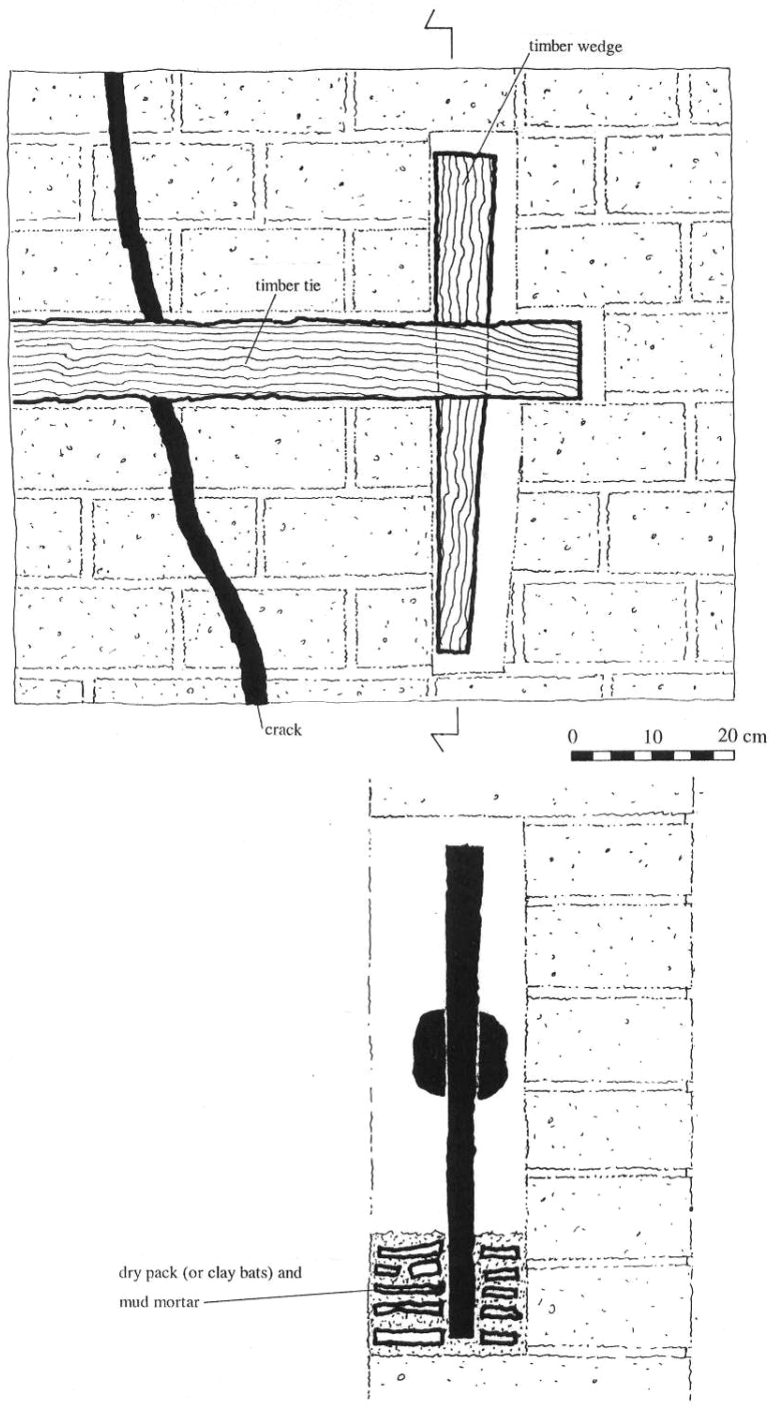


Fig. 7. Traditional stitching method for wall cracks. The timber tie ends on the right hand side with another wedge similar to the one on the left. The idea behind this method is to connect the two parts of wall that are separated by the crack.

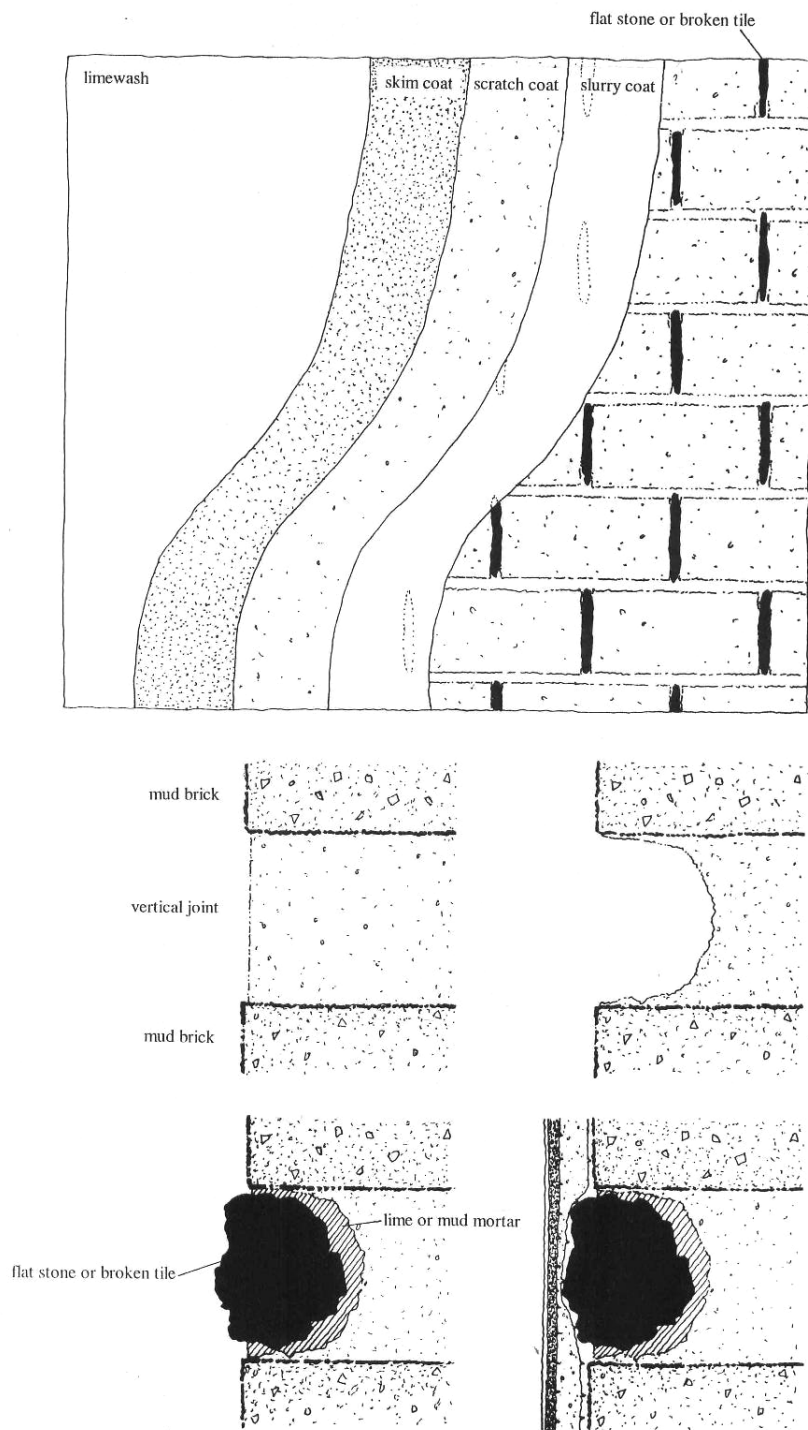


Fig. 8. Traditional repair method for shallow erosion

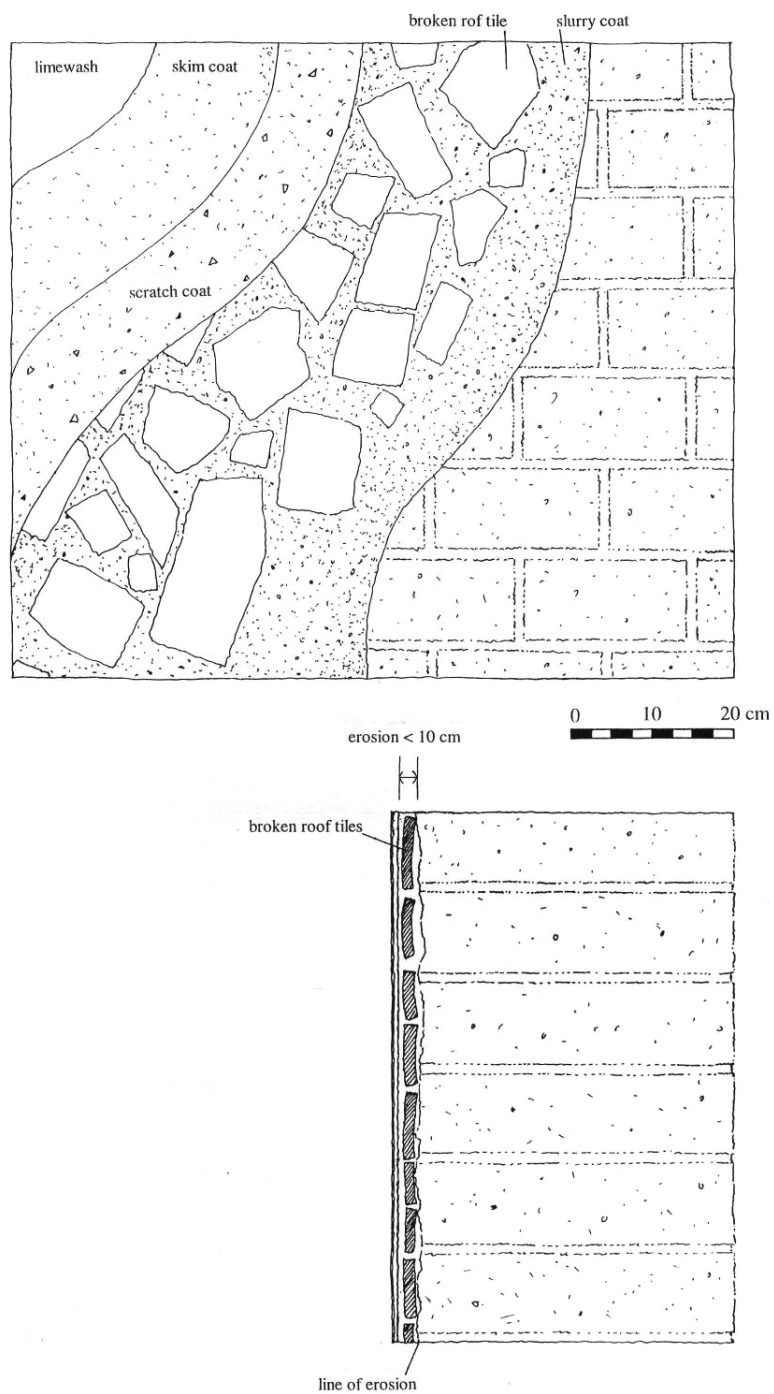


Fig. 9. Traditional repair method for shallow erosion (< 10 cm)

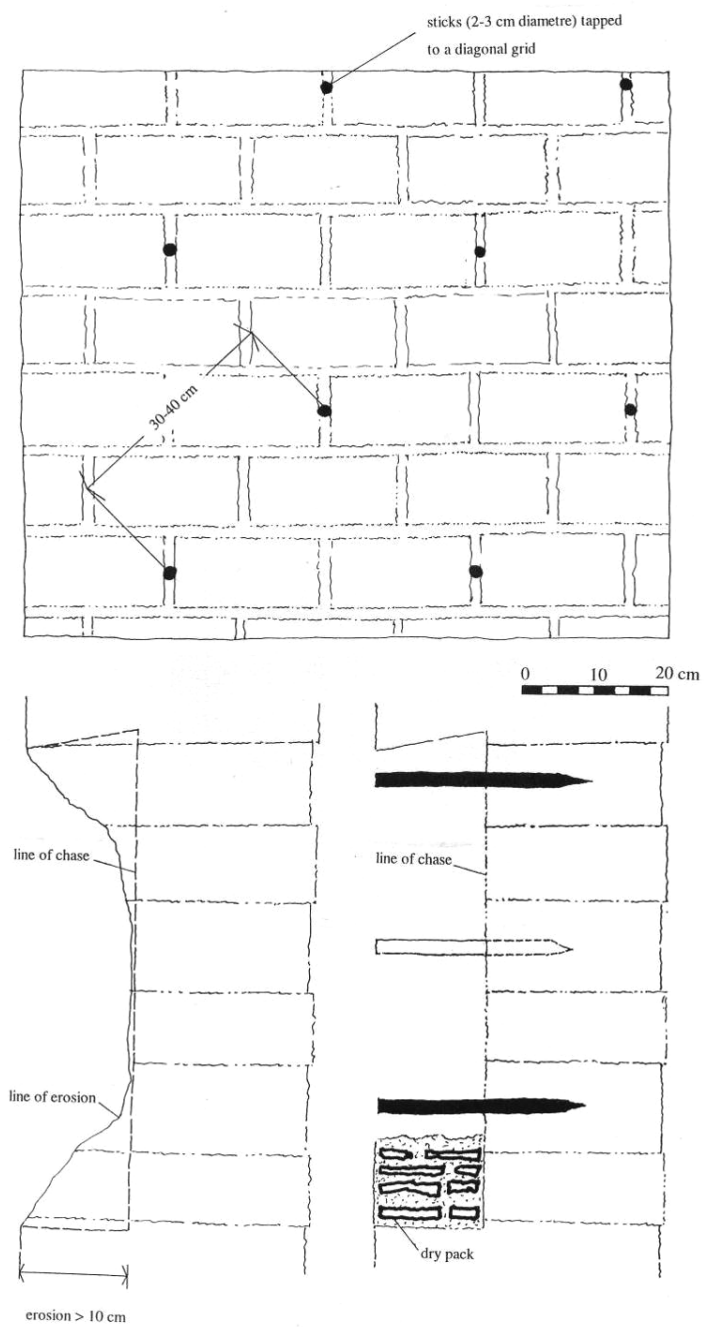


Fig. 10. Traditional repair method for deep erosion (> 10 cm)

¹ For the origin of the word Campidano, see Massimo Pittau, 'L'Origine del Nome Campidano', *Ichnusa* **18**, Year V (1957), 61-64 (61)

² For the archaeological evolution of the use of earth as a building material in Sardinia, see Gennaro Pesce, *Nora, Guida agli Scavi* (Bologna, 1957), 37. See also Marina Valdès, 'L'isola di San Simone nella Laguna di S.Gilla' in *Archivio Storico Sardo, Miscellanea in onore di Giovanni Todde* (Cagliari, 1986), 208-209 (208). For a more anthropological study of Sardinian dwellings, see Maurice Le Lannou, *Pastori e Contadini di Sardegna* (Cagliari, 1979). See also Giulio Angioni, *Sa Laurera. Il Lavoro Contadino in Sardegna* (Cagliari, 1976). For a typological study of vernacular Campidano, see Osvaldo Baldacci, 'L'Ambiente Geografico delle Case di Terra in Italia', *Rivista Geografica Italiana*, **LXV** (1958), 13-43 and Vico Mossa, *Architettura Domestica in Sardegna* (Sassari, 1957)

³ Le Lannou, op. cit., 183

⁴ Massimo Alvito, 'Campidano' in Paul Oliver (ed.), *Encyclopedia of Vernacular Architecture of the World, Cultures and Habitats* (Cambridge, 1997), 1546.

⁵ Giulio Angioni, *Rapporti di Produzione e Cultura Subalterna. Contadini in Sardegna*. (Cagliari: Edes Editrice, 1973), 111

⁶ Le Lannou, op. cit., 26

⁷ Mossa, op. cit., 156

⁸ Valdès, op. cit., 327

⁹ Lucio Melis, 'Preparazione dei Làdiri ed Esecuzione delle Murature' in Antonello Sanna (ed.) *Architetture in Terra* (Cagliari, 1993), 151-161 (152)

¹⁰ Giannetto Cossu, 'Su Làdiri de Samassi. Scheda Tecnica sul Processo Tradizionale di Fabbricazione del Mattone Crudo in un'Area del Capidano Centro-Occidentale' in Franco Storelli (ed.) *Habitat e Architetture di Terra* (Rome, 1996), 169-176 (p.170)

¹¹ Cossu (1996, 175)

¹² Identification is difficult because there are no laboratory tests available today for such low concentrations, as explained by Giorgio Torraca, 'Problemi di Conservazione delle Superfici Murarie Esterne' in Guido Biscontin (ed.) *Le Superfici dell'Architettura* (Padova, 1990), 13-26 (15)

¹³ Cossu, op. cit., 173

¹⁴ Cossu, op. cit., 172

¹⁵ Cossu, op. cit., 173

¹⁶ Francisco Uviña Contreras, *Adobe Architecture Conservation Handbook* (Santa Fe, 1998), 56

¹⁷ Cossu, op. cit., 173

¹⁸ Clough William-Ellis, *Building in Cob, Pisé, Chalk and Clay. A Renaissance* (London, 1919), 44

¹⁹ Jean Pierre Adam, *La Construction Romaine: Matériaux et Techniques* (Paris, 1984), 238

²⁰ Gordon T Pearson, *Conservation of Clay and Chalk Buildings* (London, 1992), 93